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# Developing a Community of Practice to support the Space Engineering Higher Education Community

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## ABSTRACT

The UK-based “[Space Universities Network](#)” (SUN) was formed in 2016 with the aim of enhancing the quality of learning and teaching by providing support and resources to the space science and engineering higher education community. The goal of this research was to pilot the running of this education network as a Community of Practice and then to use the existing concept of value creation to evaluate it. A Community of Practice is a recognized way of encouraging interaction and shared best practice to learn together. This paper starts with a review of Communities of Practice in the literature, then describes the process that led to the foundation of the SUN network and its evolution. The methods and process used to establish the infrastructure and regulation of the community are discussed. Next, the UK context, the aims and objectives of SUN and the membership of the community are covered. Results include newsletters and email lists which have been used as methods of communication, training of staff has been achieved through workshops by recognized experts and a curated web-based repository of resources has been used to exchange ideas for classes, icebreakers, case studies, questions, shared facilities database and practical exercises. Evaluation of the community has been carried out via a survey of members. In conclusion, a community of practice has found to be a useful vehicle to enable the space higher education community to interact and learn from each other in order to raise the level of space education in the UK. Once firmly established, it is hoped to expand the network through partnerships with similar networks in other countries.

## 1. Background

The world space economy is expected to grow to \$400 billion by 2030. The UK Space Agency has ambitious plans to capture a larger share of this market. Training new space engineers and scientists is critical to fulfilling this need. The UK-based “[Space Universities Network](#)” (SUN) was formed in 2016 with the aim of enhancing the quality of learning and teaching in this area through a ‘community of practice’ (CoP). Previous authors have said: “*The growth of any craft depends on shared practice and honest dialogue among the people who do it. We grow by private trial and error, to be sure--but our willingness to try, and fail, as individuals is severely limited when we are not supported by a community that encourages such risks*” [1]. The concept of CoPs was first proposed by Lave and Wenger, who defined them as: “*groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly*” [2]. CoPs have been used with great success in industry, IT and healthcare [3], [4]. They have also emerged as fertile ground for innovation, professional learning and developing scholarship of teaching and learning skills in Higher Education [5][6]. Faculty development CoPs have also been shown to have been effective in improving participants' awareness of, attitudes toward, and adoption of research-based educational approaches [7]. The CoP concept can be used to provide some scaffolding and guidance for the development of groups, teams, and networks, as guidance in the literature is available for setting up, maintaining and sustaining them [8]–[10]. Although there is little in the literature on specifically Engineering Education CoPs, there are already many Higher Education CoPs.

However, when it comes to evaluating the CoP, there are fewer studies. According to previous work: “*The considerable variation in the structure and function of CoPs makes it difficult to evaluate their effectiveness*” [9]. Although, 19 articles are assessed in a scoping review [11]. ‘Value creation’, as defined by Wenger, Trayner and de Laat [12] provides a simple yet flexible framework, already used in an educational context, upon which to build questions to establish value. The value creation is divided into 5 cycles of value and these cycles define a spectrum of value creation, from everyday interactions to impacts outside the community. The goal of this research is to pilot the running of this education network as a Community of Practice and then to use the existing concept of value creation to evaluate it.

## 2. Methodology

This work has followed Wenger's [5] and Salmon's [6] recommendations for setting up a CoP. These follow a series of steps starting with establishing the community, setting the strategic context, defining the areas of expertise through to nurturing and integrating the community in its environment. The community was formed initially by 3 members of the Space Engineering community meeting to discuss ideas for teaching and learning in 2015 and then has spread by open invitation to UK Higher Education institutions ever since. The process of development is described in Figure 1.

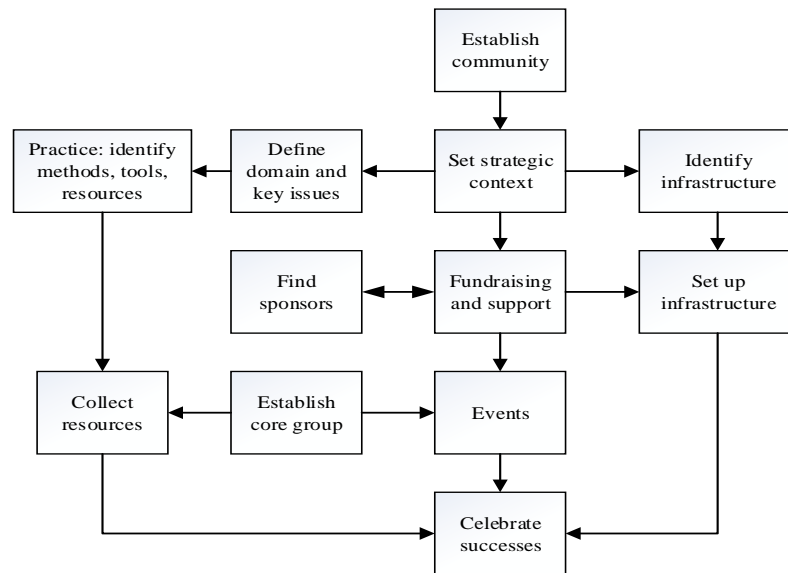


Figure 1: Methodology used for establishing the SUN community of practice

When a sufficient number of members was reached, a workshop was held to invite all members to discuss how to set up this new community. A debate was held to discuss the necessity and UK strategic context for the community. The domain and key issues were identified during the workshop to look at the areas and issues to be addressed by the community (discussed in section 3). Once these issues had been identified then a list of potential useful resources, tools and methods were discussed. Next the necessary infrastructure of the community was suggested to consist of website, academic listserve email list and networking workshops. After this first workshop, the next step was to apply to a competitive funding call and to be awarded funding by the UK Space Agency. This paid for the commissioning of the database-backed website which would host many of the resources and for the launch of the organization at the UK Space Conference in Manchester 2017. Establishing a core group who would drive forward the community was key to ensuring the diverse voices in the community were heard. This group was called the SUN working group and held regularly meetings (aimed roughly at the solstices and equinoxes!). Subgroups were formed later to look at various work streams. These working groups propose ideas for events, drive the collection of resources, look for funding, liaise with industry and media. A set of Terms of Reference and a Strategy document were written jointly by the group and these have helped focus efforts. As Lave and Wenger point out, it is vital to celebrate the successes of the network and its members. This is done regularly via the medium of an email newsletter. After one year of operation of SUN, an anonymous survey of the members via electronic means has been performed. This survey was based on the cycles of value creation described in Wenger, Trayner, de Laat's work [13], the full questions are listed in Appendix A.

## 3. Results

### 3.1. Context and Domain

Successful UK University science and engineering departments have struggled to maintain the level of laboratory participation and build and test projects, as accepted University undergraduate places have increased from 271000 in 1994 to 535000 in 2016 [13]. It is recognized that there is a shortfall in Science, Engineering, Technology and Maths graduates and a report by the industry body Engineering UK suggests that this is as much as 20000 graduates a year [14]. A UK accreditation body called the 'Institute of Engineering and Technology' has produced

a report on skills based on surveys of employers. These established that 62% of engineering employers are concerned about graduate skills, of those, 59% say that is because Engineering and technology degrees do not develop sufficient practical skills and 68% are concerned that the education system will struggle to keep up with the skills required for technological change [15]. Against this backdrop, SUN members wish to enable the developing, sharing and promotion of effective practice and innovation in the delivery of university-level space science and engineering curricula.

The value of the Space University Network domain comes from its collective intention to advance learning in Space Higher Education. This shared commitment to this domain and to the group of people who care about it, is, in itself, a learning resource. Over a period of time the experiences and learning of the community will become a form of shared practice – a shared repertoire of case studies, contacts, questions, equipment, concepts and perspectives. The exact domain of interest was defined at a workshop of 25 of the members of the community. All participants wrote down their own issues and challenges that they faced in their everyday experience of teaching and learning space science and engineering. Then together they formulated some ideas and solutions which could help with some of these issues (see Practice section 3.3). Bearing these in mind, they together formulated the main objective of SUN, which is to facilitate the creation of a skilled workforce of graduates who can meet the challenges for the future scientific and commercial exploration and exploitation of space. The network aims to address this need by helping to inspire students to join the space sector and ensuring they are well equipped by University to contribute.

The overall aims and objectives of SUN are to:

- Improve the competitiveness of the UK's future Space workforce, in particular addressing the shortage of skilled Science Technology Engineering and Maths (STEM) graduates.
- Share space teaching ideas, providing new ideas, broadening topics covered and enriching the curricula
- Liaise with industry on graduate requirements to meet the increasing demand for professional scientists and engineers, and to promote subsequent career development
- Encourage increased reflection in space education practice and material
- Provide a coherent approach to research and trialing new pedagogical methods across multiple institutes and a wider student base
- Provide awareness of space degrees and space employment market, with commensurate increase in student numbers
- Opportunities for networking and collaboration in teaching and research
- Provide access to resources: facilities, equipment and specialist expertise
- Influence policy on the teaching of space science and engineering to produce graduates prepared for tomorrow's industry and research.

### 3.2. Membership of the Community

The membership of the network has grown from 3 to 48 over the past 2 years. These members come from 28 different Higher Education Institutions in the UK (Figure 2). This is not an exclusive 'club', all Institutions of Higher Education interested in Space in the UK have been invited to join, and collaboration with other organizations, including Space Industry has been encouraged. Indeed, the subject of the second SUN workshop had an industry-academia theme: "What does the Space Industry want from graduates?". The majority of members are in Engineering departments, but at a recent meeting, the community voted to open the doors to space scientists as well as engineers. SUN also works hand in hand with partner organizations including the student organization: Students for the Exploration and Development of Space (SEDS), the Space Catapult (a government innovation hub), the Space Action Network (a network focused on research), ESERO-UK (European Space Agency outreach organization) and others.

### 3.3. Practice

The aim of SUN is to support the Space HE community in the

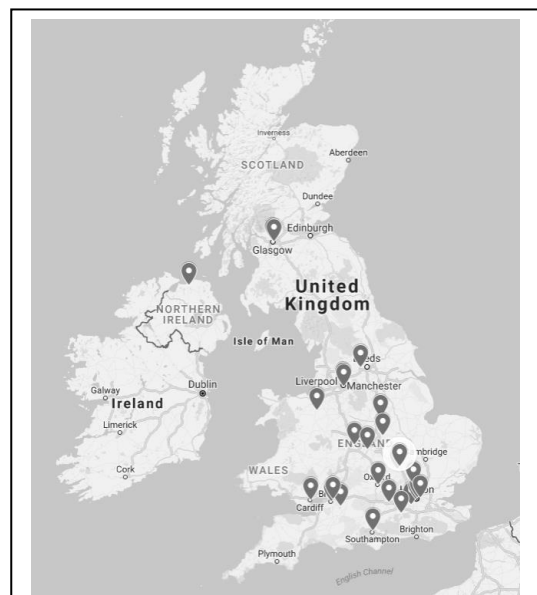


Figure 2: Space Engineering staff from 28 Universities across the UK have signed up to be members of SUN.

UK by sharing and encouraging effective practices in space teaching and learning across the UK University sector. The main method of communication between members is the email list, through which members put out notices of events that they are running (either for students or for staff), posts that they are advertising, outreach events, research collaborations etc. The newsletter is used to draw members attention to joint events, new website resources initiatives and there is an interview with a different member each month. Annual workshops have been centered on topics of interest to members, who are always striving to provide the best learning experience for their students by learning themselves. SUN members were polled via email for topics of interest for workshops. One of the goals of SUN has been to liaise with industry about curricula and skills, so the theme of first workshop was proposed by members to be “What does the Space industry want from graduates?” Leaders of successful space companies, agencies and accreditation institutions were invited to give talks to SUN members about the qualities and skills they were looking for in University graduates. The main messages of the industry leaders were summarized in an article on the event by a student careers organization here: [https://spacecareers.uk/?p=article\\_public&id=224](https://spacecareers.uk/?p=article_public&id=224). The talks were filmed and are available on YouTube here: <https://www.youtube.com/channel/UC0jythXs3CuC-Ld2i-qVDpg/videos>. This year members have chosen to learn about new uses of space data, with the help of the Satellite Applications Catapult (an innovation and technology company). The principle being that if the SUN members learn about new emerging fields, then they can better guide their students’ learning in these areas. Ordinarily, the SUN members might only attend a workshop centered on their research domain. These workshops, as with all such events, also provide a chance for networking among peers and examples of the value of this are given in section 3.4. Short courses on specialist subjects open to students have also been organized. These are arranged in tandem with the student organization SEDS who can promote them. For example, the University of Leicester provided a course on orbital mechanics and Kingston University London have provided a course on rocketry. One of the key attractions of SUN is the curated web-based repository of resources to support teaching and learning which has been created. This is being built up by members of SUN who can themselves log on to the website and view, upload and download resources.

The resource bank contains:

- a. Case studies of practical teaching ideas - satellites built in soda cans, water-powered rockets, incident investigation reports for space mission failures.
- b. Class resources – videos clips, icebreakers, useful articles on scholarship of teaching and learning
- c. Question bank of questions on specific space topics with topic tagging for search purposes
- d. Database of guest lecturers and topics
- e. Database of external examiners
- f. Database of laboratory and test facilities including specialist equipment for satellite testing
- g. Links to our partner space careers website: [spacecareers.uk](https://spacecareers.uk) and outreach website [ESERO UK](https://esero.uk).

Some of these resources are visible (but not downloadable) to external viewers at:

<https://www.spaceuniversitiesnetwork.ac.uk/resource-bank>. Many of the resources are practical projects to respond to demand from both employers and students.

### 3.4. Evaluation

It is challenging to measure the benefits of communities of practice as these often include the evolution of connections among practitioners, relationships based on trust, and a language and context shared by community members. The learning that evolves from these communities is often collaborative, in which the collaborative knowledge of the community is greater than any individual knowledge. So, the joint projects which emerge from the community are evidence of success of that community. At the first workshop, there were 25 attendees, at the UK Space Conference launch and 2<sup>nd</sup> workshop on “What does the Space Industry want from graduates?” there was a mix of 49 SUN members, industry, recruiters, students and members of SEDS. Website analytics reveal a peak of activity just after the website was launched at the UK Space conference and that the majority of the website users are based in the UK, are between 18-24 and are looking for space University courses. This useful information emphasized the importance of the link between our website and the student organization SEDS who host a courses website. An anonymous electronic survey of members was performed and 12 members responded. This survey has been based upon the value creation framework proposed by Wenger, Trayner and de Laat [12]. Questions (Appendix A) have used the 5 cycles of value as a basis.

For the first cycle of value: “immediate value- indicators of activity”, the results showed that:

- 24% of members had met someone new
- 21% had met someone they already knew again

For the second cycle of value: “potential value- knowledge capital” the results showed that:

- 31% had gained a useful piece of information
- 21% had passed along a piece of information
- 21% had given input to the network.

For the 3<sup>rd</sup> cycle of value, “applied value: indicators of changes in practice”, results showed that:

- 21% had gained a new perspective or learned about something new,
- 9% had tried a new suggestion or changed the way they teach something.
- 1 member had tried ‘none of these’

Further evidence included: members being invited to other institutions to give guest workshops on teaching ideas that they have developed, members being invited to be external examiners at other institutions, the potential to highlight academic facilities to potential UK users, for example specialized laboratories at Kingston University London and the University of Birmingham, ways to introduce younger colleagues to other experienced academics in space, source of enriching / enhancing ideas for course, e.g. inter-university competitions to build rockets and microsatellites.

Comments from the survey question 5: “what, if anything, have you gained from SUN?” included:

- *So far, it's early days, but I think it's helpful to build a network of practice in Space-related teaching.*
- *Developed links for outreach activities and potential extra-curricular Competition development*
- *Didn't know about GMAT orbit modelling software before*
- *Access to high quality teaching material, for example course on use of orbit modelling*
- *Being part of a supportive like-minded community.*

Answers to question 6: “how can SUN improve?” included:

- *More website resources*
- *Links to other equivalent networks in other countries might be useful - both for training (placements, internships, exchanges) and/or for resources.*

#### **4. Discussion**

SUN is in its early stages yet, and whilst the worth for some of its participants has been established, its value to those who did not participate in the survey cannot be evaluated. Those who participated in the survey are likely to be the most active members of the network. The challenge of a community is to initiate and then maintain engagement and activity, so it would be useful to find out what would help those who have not yet participated to contribute. There needs to be a continual dialogue about the reason and purpose of the community, regular communication, ideas need developing, members continue to help each other and shared resources require further development. All of these things help keep the community feeling alive. Further recommendations on creating and running such communities are provided in the literature [2-10].

The evaluation shows that some value in cycles 1, 2 and 3 have been created by the network, however cycles 4 and 5 were not evaluated at this stage as it was considered that the network was too young to provide this level of value. The evaluation framework used in this work is based on the concepts of value creation and like many evaluation tools requires many questions to be answered by participants. This was not possible through the medium of a survey to time-poor academics and is a limitation of the current work. The main people who benefit from the value are the participants themselves, both individually and collectively. But there are other stakeholders whose may also benefit from the created value. These include the Higher Education communities in which members operate (in particular the students), the funders who have sponsored the network, and the wider community in which the network operates, in this case the UK Space science community and UK Space Industry.

#### **5. Further work**

It is intended to ask for personal narratives of some more active members of SUN. These narratives will be distributed to the community via the newsletter as ‘aspirational’ narratives. It is hoped that this will demonstrate the value that it is possible to gain to all members of the community.

Whilst value to some of its members has been established, it is harder at this stage to measure the impact on the students, who are also stakeholders. Whilst resources have been created which students can directly benefit from. Further work continues to build up the teaching resources on the website, including a series of case studies which will be produced in the next year.

Currently further funding is being sought in order to expand the network to space science, as well as engineering. Also, modes of continuing the dialogue with industry will shortly be established, as industry have shown a great interest in working with the network. They cite the ease of access to an entire community as their interest.

## 6. Conclusions

The Space Universities Network is a community of space science and engineering Higher Education staff at UK Universities who are interested in developing their teaching and learning skills. Casting the network as a community of practice has facilitated the scaffolding the growth and support structure for the network, whilst allowing it to evolve according to the needs and wishes of its members. This work has described the process by which the community has developed, the membership, the domain and its practice. Using the concept of value creation has allowed an evaluation of the CoP with assessment of the different levels of value added by the community. This work demonstrates the value of such a community to its members even in the first years of its inception.

## Acknowledgements

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#### **Appendix A: Survey questions**

1. Have you attended any SUN events?
2. Do you read the SUN jisc emails?
3. Through SUN, have you done any of the following? (Please select all that apply). Options: Met someone new/ Met someone you already knew /Asked someone a question through the network or at an event / Passed along a piece of information or request /Given input / None of these
4. Through SUN have you done any of the following (please select all that apply): Gained a useful piece of information /Gained a new perspective /Learned about something new /Implemented a new lesson idea /Tried a suggestion /Changed the way you teach something /None of these
5. What have you gained from SUN? Please give examples of any invitations/events/research/teaching that have arisen out of your experience.
6. How can SUN improve?

#### **Appendix B: Member Universities**

Cardiff University, Cranfield University, Glasgow University, University of Hertfordshire, Imperial College, Kingston University London, Open University, Queen Mary College, Southampton University, Strathclyde University, Ulster University, University of Bath, University of Birmingham, University of Bradford, University of Bristol, University College London, UCL Mullard Space Science Laboratory, University of Leicester, University of Manchester, University of Nottingham, University of Oxford, University of Reading, University of Salford, University of Southampton, University of Strathclyde, University of Surrey, University of Warwick, University of West of England, Wrexham Glyndwr University.